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(21) International Application Number: ✓PCT/EP89/01017 (22) International Filing Date: 30 August 1989 (30.08.89) (30) Priority data: 239,721 1 September 1988 (01.09.88) US (71) Applicant: APPLIED RESEARCH SYSTEMS ARS HOLDING N.V. [NL/NL]; John B. Gorsiraweg 6, Cu-raçao (AN). (72) Inventors: CHAPPEL, Scott, C. ; 39 Hancock Street, Bos-ton, MA 02114 (US). NUGENT, Noreen, P. ; 38 West-gate Road, Framingham, MA 01701 (US). (74) Agent: RITTER, Stephen, David; Mathys & Squire, 10 Fleet Street, London EC4Y 1AY (GB).		(81) Designated States: AT (European patent), AU, BE (Euro-pean patent), CH (European patent), DE (European pa-tent), DK, FI, FR (European patent), GB (European pa-tent), IT (European patent), JP, KR, LU (European pa-tent), NL (European patent), NO, SE (European patent). Published With international search report.			
(54) Title: METHODS FOR PRODUCING GONADOTROPIN AND TSH SUPER-AGONISTS					
<table border="0"> <tr> <td colspan="2" data-bbox="245 1192 714 2060"> (57) Abstract Methods are provided for produ-cing super-agonist hormones, which hor-mones are those having the common alpha subunit of the gonadotropins, generally comprising the transformation of host cells with recombinant DNA comprising a first DNA sequence coding for an alpha subunit from an equine animal species and a second DNA sequence coding for a beta subunit from a non-equine species. The preferred hormone comprises an equine alpha subunit and a bovine, por-cine or human beta subunit of LH, FSH, CG or TSH and exhibits a greatly in-creased activity. </td><td data-bbox="714 1192 1557 2060"> <div style="text-align: right;">EQUINE ALPHA SUBUNIT cDNA AND AMINO ACID SEQUENCE</div> <div> 1 GGGGGGGGGGGGGGGGGGGGGTCTCTGAACACATCCTACAAAAAGTCCAGAGGAAGAAG 60 MetAspTyrTyrArgLysHisAlaAlaValIleLeuAlaThrLeuSerValPheLe 61 AGCCATGGATTACTACAGAAAACATGCAGCTGTCTCCTGGCCACATTTGTCCTGTTTCT 120 uHisIleLeuHisSerPheProAspGlyGluPheThrThrGlnAspCysProGluCysLy 121 GCATATTCTCCATTCTTTCTGATGGAGAGTTTACAACGCAGGATTGCCAGAAATGCAA 180 sLeuArgGluAsnLysTyrPhePheLysLeuGlyValProIleTyrGlnCysLysGlyCy 181 GCTAAGGGAAAACAAGTACTTCTCAAAGTGGCGTCCCGATTACCAAGTGAAGGGCTG 240 sCysPheSerArgAlaTyrProThrProAlaArgSerArgLysThrMetLeuValProLy. 241 CTGCTTCTCCAGAGCGTACCCCACTCCAGCAAGGTCCAGGAAGACAATGTTGGTCCCAAA 300 sAsnIleThrSerGluSerThrCysCysValAlaLysAlaPheIleArgValThrValMe 301 GAACATCACCTCAGATCCACATGCTGTGTGGCCAAAGCATTTATCAGGGTCACAGTCAT 360 tGlyAsnIleLysLeuGluAsnHisThrGlnCysTyrCysSerThrCysTyrHisHisLy 361 GGGAAACATCAAGTTGGGAGAACCACCCAGTGCTATTGCGACACTTGCTATCACCACAA 420 sIleEnd 421 GATTAAATGTTTCACCAAGTGCCTTGTGGATGACTGCTGATTTCACCCCCCCCCCCCCC 480 </div> </td></tr> </table>			(57) Abstract Methods are provided for produ-cing super-agonist hormones, which hor-mones are those having the common alpha subunit of the gonadotropins, generally comprising the transformation of host cells with recombinant DNA comprising a first DNA sequence coding for an alpha subunit from an equine animal species and a second DNA sequence coding for a beta subunit from a non-equine species. The preferred hormone comprises an equine alpha subunit and a bovine, por-cine or human beta subunit of LH, FSH, CG or TSH and exhibits a greatly in-creased activity.		<div style="text-align: right;">EQUINE ALPHA SUBUNIT cDNA AND AMINO ACID SEQUENCE</div> <div> 1 GGGGGGGGGGGGGGGGGGGGGTCTCTGAACACATCCTACAAAAAGTCCAGAGGAAGAAG 60 MetAspTyrTyrArgLysHisAlaAlaValIleLeuAlaThrLeuSerValPheLe 61 AGCCATGGATTACTACAGAAAACATGCAGCTGTCTCCTGGCCACATTTGTCCTGTTTCT 120 uHisIleLeuHisSerPheProAspGlyGluPheThrThrGlnAspCysProGluCysLy 121 GCATATTCTCCATTCTTTCTGATGGAGAGTTTACAACGCAGGATTGCCAGAAATGCAA 180 sLeuArgGluAsnLysTyrPhePheLysLeuGlyValProIleTyrGlnCysLysGlyCy 181 GCTAAGGGAAAACAAGTACTTCTCAAAGTGGCGTCCCGATTACCAAGTGAAGGGCTG 240 sCysPheSerArgAlaTyrProThrProAlaArgSerArgLysThrMetLeuValProLy. 241 CTGCTTCTCCAGAGCGTACCCCACTCCAGCAAGGTCCAGGAAGACAATGTTGGTCCCAAA 300 sAsnIleThrSerGluSerThrCysCysValAlaLysAlaPheIleArgValThrValMe 301 GAACATCACCTCAGATCCACATGCTGTGTGGCCAAAGCATTTATCAGGGTCACAGTCAT 360 tGlyAsnIleLysLeuGluAsnHisThrGlnCysTyrCysSerThrCysTyrHisHisLy 361 GGGAAACATCAAGTTGGGAGAACCACCCAGTGCTATTGCGACACTTGCTATCACCACAA 420 sIleEnd 421 GATTAAATGTTTCACCAAGTGCCTTGTGGATGACTGCTGATTTCACCCCCCCCCCCCCC 480 </div>
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METHODS FOR PRODUCING GONADOTROPIN AND TSH SUPER-AGONISTS5 Field of Invention

 This invention relates to the expression, by recombinant DNA technology, of unique gonadotropin hybrid molecules. Gonadotropin molecules are dimeric in nature, containing a common alpha subunit and a hormone-specific beta subunit. This application
10 describes the technology to produce large amounts of a gonadotropin that is composed of an alpha subunit ordinarily found in one animal and the beta subunit from another species.

Background of Invention

15 It has been known for almost 20 years that the glycoprotein hormones luteinizing hormone (LH), follicle stimulating hormone (FSH) and thyroid stimulating hormone (TSH) are dimeric molecules consisting of a common alpha subunit and a hormone specific beta subunit (G. Bousfield et al., Mol. Cell. Endoc.
20 40:67-77 [1985]; T-H Liao et al., J. Biol. Chem. 245:3275-3281 [1970]; J.G. Pierce et al., Ann. Rev. Biochem. 50:465-495 [1981]). While the genes that encode each of the three beta subunits are unique and have different chromosomal assignments, a single gene is responsible for the production of the same alpha subunit for
25 each hormone (J.C. Fiddes et al., In: Bioregulators of Reproduction, Acad. Press. pp279-304 [1981]). Recombination of the beta subunit of LH, FSH or TSH with the alpha subunit of another

results in the production of a hybrid molecule with biologic activity of the beta subunit (G. Bousfield et al., Mol. Cell. Endoc. 40:67-77 [1985]; L.E. Reichert et al., Endocrin. 87:531-534 [1970]; J.G. Pierce et al., J. Biol. Chem. 246:2312-2324 [1971]). Thus, dissociation of bovine LH into the alpha and beta subunits and mixing of the bovine LH alpha with free bovine beta TSH will produce a hybrid molecule with bovine TSH bioactivity.

It was also noted that free subunits obtained from dissociated hormones exhibit little or no biologic action when added to target cells (K.J. Catt et al., J. Clin. Endocrin. Metabol. 36:73-79 [1973]; J.F. Williams et al., Endocrin. 206:1353-1359 (1980)). Only dimers of the alpha and beta subunits are biologically active. Studies have demonstrated that both the alpha and beta subunits must interact with the receptor to elicit a biological response (W.R. Moyle et al., Proc. Natl. Acad. Sci. USA 79:2245-2250 [1982]). Further, it has been demonstrated that the carbohydrate moieties present upon the subunits (in particular, the alpha subunit) are essential for transduction of this extracellular hormonal signal to an intracellular biological action, usually through the action of the adenylate cyclase system (M.R. Sairam et al., Science 229:65-67 [1985]).

Scientists have examined the effects of recombination of subunits obtained from hormones of different animals. When the amino acid sequence is compared between the ovine, bovine, porcine, and human alpha subunits, a striking sequence homology is observed (J.G. Pierce et al., Ann. Rev. Biochem. 50:465-495 [1981]). It has been demonstrated that human alpha subunit and

ovine LH beta subunit, when combined, exhibited LH bioactivity (L.E. Reichert et al., Endocrin. 87:531-534 [1970]). As a result of the gene conservation of gonadotropin subunits between species, almost all inter-species hybrid molecules have been shown to be biologically active. Many other studies have confirmed that recombining subunits of LH obtained from different species resulted in the production of hormones with approximately equivalent biologic activities (T-H Liao et al., J. Biol. Chem. 245:3275-3281 [1970]; L.E. Reichert et al., Endocrin. 87:531-534 [1970]; J.G. Pierce et al., Ann. Rev. Biochem. 50:465-495 [1981]).

Much less is known about structure-function relationships of equine gonadotropins. Equine LH and FSH have recently been purified from horse pituitary glands and the biochemical structure and biologic activity of the molecules studied. These molecules exhibit some unique features. First, equine chorionic gonadotropin (the hormone of pregnancy analogous to human chorionic gonadotropin) exhibits both LH and FSH bioactivity (Y. Combarrous et al., Endocrin. 115:1821-1827 [1984]). Secondly, equine FSH exhibits much greater potency in a number of bioassay systems, when compared on a molar basis, to rat or porcine FSH (F. Guillou et al., Biochem. Biophys. Acta. 887:196-203 [1986])). Thirdly, the equine LH molecule exhibits at least 100 times greater bioactivity on a molar basis than LH molecules purified from sheep or porcine pituitaries (G. Bousfield et al., Mol. Cell. Endocrin. 40:69-77 [1985]). Finally, the equine LH beta subunit exhibits a C-terminal extension that is rich in serine-linked (O-linked) oligosaccharides, unlike other LH subunits, but quite

similar to the C-terminal peptide of hCG (G.R. Bousfield *et al.*, J. Biol. Chem. 259:1911-1921 [1984]).

When hybrid gonadotropin molecules were formed with purified equine subunits combined with the corresponding subunits of other species, yet another interesting phenomenon was observed. A hybrid LH molecule, that contains the alpha subunit of equine and the bovine or porcine β subunit of LH, results in an LH molecule with 10-40 times the biopotency of the corresponding homologous LH molecule. No teaching, however, was provided in order to produce such molecules in useful quantities or purities.

In the original paper that describes the unusually amplified bioactivity of hybrid LH molecules with equine alpha (up to 49 times as active as the homologous LH species) the authors suggest that this phenomenon may be the result of the unique tyrosine-histidine transposition observed at the C-terminus of this equine subunit (G. Bousfield *et al.*, Mol. Cell. Endocrin. 40:69-77 [1985]).

Superovulation of cows and other animals is performed routinely to expand herd size with genetically superior animals. Induction of superovulation with a hormone of greater bioactivity would be highly desired since such require less hormone, thus reducing costs. While it appears that a hybrid gonadotropin might accomplish this, only conventional biochemical methods are available to produce these unique hybrid molecules. Such methods would rely upon pituitary glands obtained from horses and cows which

could not be supplied in adequate quantities for continuous commercialization. Additionally, the cost of purification, dissociation, rehybridization and purification would be much too great to be of conventional value.

5 It is one aspect of the present invention to provide methods and technology to produce large amounts of a superactive hybrid agonist of bovine FSH.

10 As the activity of the beta subunit can be greatly enhanced by the addition of an equine alpha subunit, it should be understood that any known utility of proteins having the common alpha subunit of the gonadotropins, such as human chorionic gonadotropin, luteinizing hormone, follicle stimulating hormone and thyroid stimulating hormone, in any species other than equine, can be greatly enhanced by creating a hybrid molecule with an equine
15 alpha subunit and the beta subunit of the hormone of interest. Thus, the treatment of sterility in humans can also be greatly enhanced by using a chimeric hybrid of human FSH, for example, and an equine alpha unit.

20 Thus, it is another aspect of the present invention to provide methods and technology to produce large amounts of a super-active hybrid agonist of any hormone having the common alpha subunit of the gonadotropins, including human hormones.

Summary of Invention

25 In accordance with these aspects of the instant invention, there are provided new methods for producing large quantities of super-active hormones having the common alpha subunit of

the gonadotropins, such as LH, FSH, CG, and TSH, and preferably bovine gonadotropins, utilizing recombinant DNA methods. The preferred molecules advantageously would be used in the superovulation of bovine animals for the breeding of preferred traits. The new methods of the instant invention produce the hybrid molecule (preferably equine α /bovine LH β or, more preferably, bovine FSH β) super-agonist in gram amounts. The agonist of the instant invention may be advantageously produced at generally reduced cost, as compared with conventional techniques.

Further aspects of the present invention include host cells and germ cells transformed according to the present invention as well as the essentially pure hybrid chimeric proteins produced according to the present invention.

Brief Description of the Figures

Further undertaking may be had by study of the accompanying figures wherein:

Figure 1 shows the nucleotide and amino acid sequence of equine α cDNA;

Figure 2 shows the nucleotide and amino acid sequence of bovine β FSH;

Figure 3 shows bovine Papilloma virus based expression vector with BamHI and BglII cloning site.

Detailed Description of Invention and Best Mode

In order to produce the essentially pure hybrid hormones in accordance with the present invention, a eukaryotic host cell is transformed with a vector comprising a promoter region, a first DNA sequence coding for an equine α subunit of a hormone which has the common α subunit of the gonadotropins, and a second DNA sequence coding for a β subunit of a hormone which has the common subunit of the gonadotropins, from a non-equine animal species. The first and second DNA sequences are in transcriptional reading frame with the promoter. The transformed eukaryotic host cells are then cultured under conditions which allow production of the hybrid hormone. The eukaryotic cell is preferably a mammalian cell and the vector preferably further includes a DNA sequence providing for self-replication.

In the most preferred embodiment, mammalian cell expressions that employ mouse C127 cells (epithelioid), capable of co- and post-translational modification of the molecules encoded by the cDNAs inserted within the expression vector, will be used. Equivalent amounts of a vector containing the equine alpha cDNA and a vector containing the bovine FSH (or LH) cDNA will be ideally transfected into C127 or other suitable host cells. Transformed cells will be identified by their characteristic piled-up appearance. The cell lines are then ideally expanded, culture producing within the culture medium, and large amounts of the recombinant DNA derived hybrid equine/bovine FSH which can then be purified.

Example 1: Equine Alpha Subunit

The cDNA clone for the equine common alpha subunit was isolated from an equine cDNA library constructed in the plasmid pBR322 at its PstI site by G-C tailing. Fresh horse pituitary glands were obtained within 10 minutes of slaughter by dissection and quick-frozen in liquid nitrogen. RNA was prepared from the tissue by pulverization and homogenization in a 1:1 mixture of phenol:100mM Na-acetate (pH=5.2) that contained 0.5% SDS at 65°C. After quick cooling on ice, the phases were separated by centrifugation at 5000 X g for ten minutes. The hot phenol extraction was repeated twice more followed by two extractions with chloroform : isoamyl alcohol (24:1). RNA was precipitated from the final pooled aqueous phase by the addition of 2.5 volumes of ethanol at -20°C.

Poly A+ messenger RNA was separated from total pituitary RNA by chromatography across an oligo (dT) - cellulose column. The mixture was passed over the column in 10mM Tris-HCl (pH=7.5) containing 0.5M NaCl and washed several times with this buffer. Poly A+ mRNA was eluted with 10mM Tris-HCl (pH=7.5) containing 1mM EDTA and 0.05% SDS.

The cDNA library was constructed from the poly A+ mRNA by standard procedures using i) avian myeloblastosis virus (AMV) reverse transcriptase to prepare first strand cDNA, and ii) both AMV reverse transcriptase and the Klenow fragment of the E.coli DNA polymerase to prepare the second strand. Following treatment with S1 nuclease, the double stranded cDNA was tailed by the addition of dC residues to the 3' hydroxyl group by the use of the

calf-thymus deoxynucleotidyl transferase. Tailed cDNA was annealed to dG-tailed pBR322 and the mixture was used to transform E.coli MC1061 (available from the American Type Culture Collection, Rockville Maryland 20852) to tetracycline resistance.

5 The library was screened with a ^{32}P labeled bovine alpha cDNA probe purchased from R. Maurer at the University of Iowa. Positively hybridizing clones were isolated and grown up for characterization by restriction enzyme digest and nucleotide sequencing. The nucleotide sequence and predicted alpha subunit
10 protein are provided in Figure 1.

Example 2: Bovine FSH Beta

The bovine FSH beta subunit cDNA was obtained from a bovine cDNA library that was established by methods substantially
15 the same as those described for equine in Example 1. The library was screened with a partial FSH beta clone purchased from Dr. R. Maurer (from the University of Iowa). Full length clones were identified, sequenced and amino acid predictions were made as shown in Figure 2.

Example 3: Expression Vector

Each of the isolated and purified cDNAs (for equine alpha and bovine FSH beta) was inserted into the expression cassette as detailed in Figure 3. This mammalian cell expression
25 vector advantageously contains the bovine papilloma virus (BPV) genome. the rat metallothionein gene promoter region, a unique

cloning site for insertion of the cDNA of interest and metallo-thionein-poly A sequences. The construction of this vector is not critical; those skilled will recognize that a plethora of alternatives abound which can be used in substitution. It will be recognized that conventional techniques such as those described in Maniatis, "Molecular Cloning, A Laboratory Manual", will readily suffice.

Example 4: Transfection of Cells

To produce cell lines that synthesize and secrete the hybrid FSH molecule, C127 mouse epithelioid cells are transfected with a mixture of two plasmids, the equine alpha cDNA in the metallothionein-BPV plasmid and the bovine FSH cDNA in this same vector. This is ideally accomplished as follows. Ten micrograms of each plasmid are added to 0.5ml of a 250mM CaCl_2 solution containing 10 μg of salmon sperm DNA as a carrier. The mixture is bubbled into 0.5ml of 280 mM NaCl, 50mM HEPES and 1.5 mM Na phosphate. The calcium phosphate precipitate is allowed to form for 30 minutes at 23°C.

Twenty-four hours prior to transfection, 5×10^5 mouse C127 cells are transferred to a 100mm culture dish. Immediately before adding exogenous DNA, the cells are fed with fresh culture medium containing 10% fetal bovine serum. One ml of the calcium phosphate precipitate is added to each dish (10ml) and the cells are incubated at 37°C for 8h. The medium is aspirated and replaced with 5ml of 20% glycerol in phosphate-buffered saline (PBS) (pH=7.0) for two minutes at room temperature. The cells are

washed once with PBS, fed with 10ml of medium and incubated at 37°C for 24h. Within 3 weeks, foci of transformed cells, characterized by their piled-up appearance, are identified, transferred to T-25 flasks and line expansion begun.

5 The equine alpha/bovine FSH dimer is ideally purified by a three step process including trisacryl Blue chromatography, ion exchange and gel filtration. Following purification and analysis of the product by a bovine beta FSH-specific radioimmunoassay, a series of in vitro FSH bioassays can optionally be performed to
10 determine the relative potency of this hybrid molecule compared with recombinant equine, bovine and human FSH. In addition, in vivo bioassays can optimally be performed to determine the potency of each of the preparations in a rodent model. The hybrid molecule will ideally exhibit enhanced biopotency.

15 While the preferred examples of the present invention use equine alpha subunit and bovine FSH beta subunit, those of ordinary skill in the art will understand that the present invention can be practiced in a similar manner using the beta subunit from any protein which has the common alpha subunit of the gonadotropins. This includes not only the gonadotropins themselves, but
20 also thyroid stimulating hormone (TSH) which also shares the common alpha subunit of the gonadotropins. Furthermore, the beta subunit may be from any desired species. In all cases the presence of the equine alpha subunit will cause a great increase in
25 the bio-activity of the hormone of the beta subunit in the species from which that beta subunit was taken. Thus, for example, if it

is desired to produce a human FSH with greatly enhanced bio-activity, a recombinant chimeric molecule can be produced in the manner discussed above to provide an alpha equine subunit bound to the human FSH beta subunit. Accordingly, in its broadest sense, the present invention relates to the production of recombinant hybrid chimeric gonadotropin hormones (or hormones having the common alpha subunit of the gonadotropin hormones) having an equine alpha subunit and the beta subunit of the hormone whose activity it is desired to increase.

It should further be understood that the hybrid molecules of the present invention produced by recombinant DNA technology can be produced in essentially pure form and, in particular, they are produced without contamination by other hormones and hormone subunits. Thus, the essentially pure hybrid molecules of the present invention are novel as prior art hybrid gonadotropins produced with classical protein chemistry techniques cannot be obtained in essentially pure form and, in particular, cannot be obtained without contamination with other hormones and hormone subunits. Thus, the essentially pure hybrid hormones of the present invention are novel and obtaining such novel hormones would not have been obvious to one of ordinary skill in the art having knowledge only of the classical protein chemistry techniques for the production of such hormones.

Those skilled in the art will readily recognize that numerous departures may be made from the procedures taught in the example without departing from either the spirit or scope of the present invention.

What is Claimed is:

1. A method for producing a hormone super-agonist, comprising:

- 5 a) transforming eukaryotic host cells with a vector comprising a promoter region and a first DNA sequence coding for an equine α subunit of a hormone which has the common α subunit of the gonadotropins and a second DNA sequence coding for a β subunit of a hormone which has the common subunit of the gonadotropins, from a non-equine animal species, said first and second DNA sequences being in transcriptional reading frame with said promoter; and
- 10 b) culturing said transformed eukaryotic host cells under conditions which allow production of the hormone super-agonist.
- 15

2. The method of Claim 1 wherein said vector further comprises a DNA sequence providing for self-replication.

20

3. The method of Claim 1 wherein said hormone having the common α subunit of the gonadotropins is chorionic gonadotropin, follicle stimulating hormone, luteinizing hormone or thyroid stimulating hormone.

25

4. The method of Claim 1 wherein said non-equine animal species is bovine.

5. The method of Claim 3 wherein said second DNA sequence codes for the β subunit of a bovine gonadotropin selected from the group consisting of FSH and LH.

5

6. The method of Claim 5 wherein said vector furthering comprises at least a portion of the bovine papilloma virus genome.

10

7. The method of Claim 6 wherein said promoter region comprises a metallothionein gene promoter region.

8. The host cell transformed according to the method of Claim 1.

9. The host cell of Claim 8 being a mammalian host cell.

15

10. The host cell of Claim 9 being a C127 cell.

11. The hormone super-agonist produced by the host cell of any of claims 8 to 10.

20

12. A hormone super-agonist in essentially pure form, free of contamination from other hormones or hormone subunits, comprising a hybrid chimeric molecule with an equine α subunit of a hormone having the common α subunit of the gonadotropins and a non-equine β subunit of a hormone having the common α subunit of the gonadotropins.

25

13. A hormone super-agonist in accordance with claim 12, wherein the hormone of said equine α subunit is not the same as the hormone of said non-equine β subunit.
- 5 14. A hormone super-agonist in accordance with claim 12, wherein said non-equine β subunit is from a bovine, ovine, porcine or human gonadotropin or thyroid stimulating hormone.

1/3

FIGURE 1

EQUINE ALPHA SUBUNIT cDNA AND AMINO ACID SEQUENCE

5

10

20

25

30

35

1 GGGGGGGGGGGGGGGGGGGGGGGCTGCTCTGAACACATCCTACAAAAGTCCAGAGGAAGAAG 60
MetAspTyrTyrArgLysHisAlaAlaValIleLeuAlaThrLeuSerValPheLe
61 AGCCATGGATTACTACAGAAAACATGCAGCTGTCATCCTGGCCACATTGTCCGTGTTTCT 120
uHisIleLeuHisSerPheProAspGlyGluPheThrThrGlnAspCysProGluCysLy
121 GCATATTCTCCATTCTTTCTGATGGAGAGTTTACAACGCAGGATTGCCAGAATGCAA 180
sLeuArgGluAsnLysTyrPhePheLysLeuGlyValProIleTyrGlnCysLysGlyCy
181 GCTAAGGGGAAAACAAGTACTTCTTCAAAGTGGGCGTCCCGATTTACCAGTGTAAAGGGCTG 240
sCysPheSerArgAlaTyrProThrProAlaArgSerArgLysThrMetLeuValProLy
241 CTGCTTCTCCAGAGCGTACCCCACTCCAGCAAGGTCCAGGAAGACAATGTTGGTCCCAAA 300
sAsnIleThrSerGluSerThrCysCysValAlaLysAlaPheIleArgValThrValMe
301 GAACATCACCTCAGAATCCACATGCTGTGTGGCCAAAGCATTATCAGGGTCACAGTCAT 360
tGlyAsnIleLysLeuGluAsnHisThrGlnCysTyrCysSerThrCysTyrHisHisLy
361 GGGAAACATCAAGTTGGGAGAACACACCCAGTGCTATTGCAGCACTTGCTATCACCACAA 420
sIleEnd
421 GATTTAAATGTTTCACCAAGTGCCTTGTGGATGACTGCTGATTTCACCCCCCCCCCCCCC 480

FIGURE 2

5

BOVINE FSH BETA cDNA NUCLEOTIDE SEQUENCE AND AMINO ACID SEQUENCE

10

MetLysSerValGlnPheCysPheLeuPhe

1 GTCAGCATCTACAGTTATCAAGTGCCAGGATGAAGTCTGTCCAGTTCTGTTTCCTTTTC 60

CysCytTrpArgAlaIleCysCysArgSerCysGluLeuThrAsnIleThrIleThrVal

61 TGTGCTGGAGAGCAATCTGCTGCAGAAGCTGCGAGCTGACCAACATCACCATCACGGTG 120

15

GluLysGluGlyCysGlyPheCysIleSerIleAsnThrThrTrpCysAlaGlyTyrCys

121 GAGAAAGAGGAATGTGGCTTCTGCATAAGCATCAACACCACGTGGTGTGCAGGCTACTGC 180

20

TyrThrArgAspLeuValTyrArgAspProAlaArgProAsnIleGlnLysThrCysThr

181 TACACCCGGGACTTGGTGTACAGGGACCCAGCAAGGCCCAATATCCAGAAAACGTGTACC 240

PheLysGluLeuValTyrGluThrValLysValProGlyCysAlaHisHisAlaAspSer

241 TTCAAGGAGCTGGTCTACGAGACGGTGAAAGTGCCTGGCTGTGCTCACCATGCAGACTCC 300

25

LeuTyrThrTyrProValAlaThrGluCysHisCysSerLysCysAspSerAspSerThr

301 CTGTACCGTACCCAGTAGCCACTGAATGTCACTGACAGCAAGTGCGACAGCGACAGCACT 360

AspCysThrValArgClyLeuGlyProSerTyrCysSerPheArgGluIleLysGluEnd

361 GACTGCACCGTGCAGGCTGGGGCCCAGCTACTGCTCCTTCAGGGAAATCAAAGAATAA 420

30

421 AGAGCACGGGATGCTTTGAGCTGCCTACCCTTATCCTAAAGGACCAAAACATCCAAGATG 480

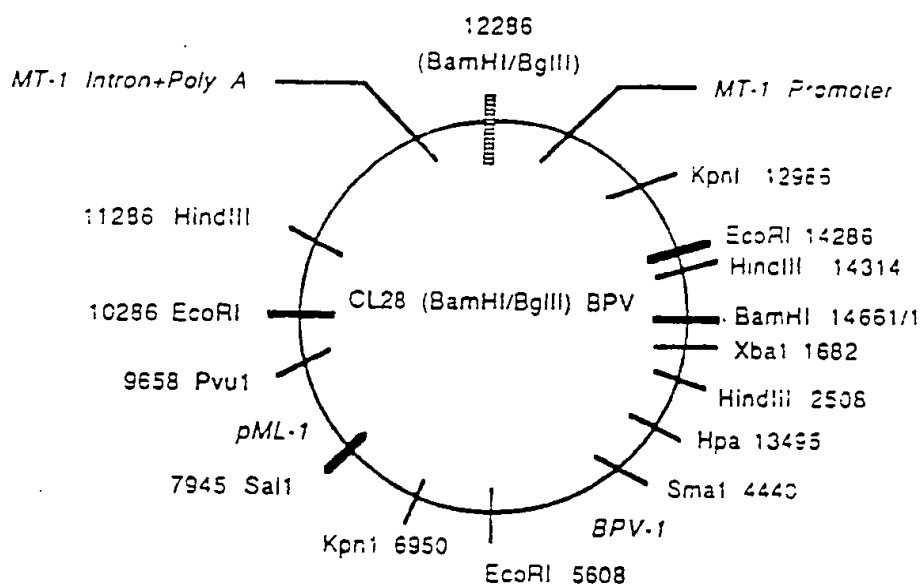
481 TCTGTGTGTACATGTGCGTAGGCTGCAGACCACCACGGGAGACCCTACTGACCTCTGCTC 540

35

541 TCCTGAC 547

3/3

Figure 3



INTERNATIONAL SEARCH REPORT

International Application No. PCT/EP 89/01017

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ : C 12 P 21/02, C 12 N 15/85, C 12 N 15/16, C 07 K 15/06		
II. FIELDS SEARCHED		
Minimum Documentation Searched *		
Classification System :	Classification Symbols	
IPC ⁵	C 12 N, C 12 P	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages †‡	Relevant to Claim No. †§
Y	Molecular and Cellular Endocrinology, vol. 40, 1985, Elsevier Scientific Publishers Ireland, Ltd (Shannon, IR), G.R. Bousfield et al.: "Hybrids from equine LH: alpha enhances, beta diminishes activity", pages 69-77, see the whole article	1-11
X	cited in the application --	12-14
Y	Journal of Endocrinology, vol. 115, 1987, Journal of Endocrinology Ltd (London, GB), F. Stewart et al.: "Nucleotide (cDNA) sequence encoding the horse gonado- trophin alpha-subunit", pages 341-346, see figure 1; page 345, column 1, lines 53-58 --	1-11
Y	WO, A, 85/01958 (REDDY et al.) 9 May 1985, see claims ----	1-11
<p>* Special categories of cited documents: †¶</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
10th November 1989	05 DEC 1989	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	T.K. WILLIS	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

EP 8901017

SA 30605

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 30/11/89. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A- 8501958	09-05-85	US-A- 4840896	20-06-89
		EP-A- 0160091	06-11-85
		EP-A- 0160699	13-11-85
		JP-T- 61500249	20-02-86

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February 14, 1997

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Re: PCT/US96/06483 International Patent
Application of The Government of the
United States of America
"GLYCOPROTEIN HORMONE
SUPERAGONISTS" (Szkudlinski *et al.*)
Our Ref.: 14014.0185/P
DHHS Ref.: E-015-96/0

Dear J.P.:

Enclosed is a copy of the PCT International Search Report dated January 29, 1997, and the references cited therein. We are pleased to note that no reference particularly relevant to the present invention was found by the search, and therefore, amending the claims in response to this Search Report is not necessary. Please note that we will have another opportunity to amend the entire application, if necessary, after the issuance of a Written Opinion.

If you have any questions, please do not hesitate to contact me.

Very truly yours,

NEEDLE & ROSENBERG, P.C.



David G. Perryman

DGP/MAW:lb

Enclosures

cc: Mariusz W. Szkudlinski, M.D., Ph.D. (w/enc.)
Dr. C.R. Creveling (w/enc.)